Impact of innovation on opinion diversity in voter models

Voter model, Opinion Diversity, Innovation, Social Dynamics, New Opinion

Extended Abstract

The study of opinion dynamics on networks is an active area in the field of network science with applications to the social sciences. Among many approaches, the voter model (VM) has been widely used to describe the dynamics of opinion formation in social systems [1]. The VM is simple and analytically tractable with methods from statistical physics and the theory of stochastic processes. Its analysis has revealed new universality classes and interesting types of collective behaviors. The VM is also related to stochastic birth–death processes in evolutionary biology, where opinion states are analogous to alleles.

The conventional VM describes a population of a finite number of individuals, who interact on regular lattices or on networks. In the simplest setup, each of these individuals has a binary opinion. The dynamics proceeds through imitation; at each step a randomly chosen agent adopts the opinion of a randomly chosen neighbor. In the long-time limit, any finite system tends to one of two consensus states, where all agents share the same opinion. The original VM has been extended in many different ways, such as including noisy voter models, nonlinear voter models, multi-state voter models, coevolving voter models, and higher-order voter models. In most of these works, the set of possible opinions that an agent can hold is fixed. However, these models often fail to capture the emergence of entirely new opinions, which can arise spontaneously in real-world scenarios

Here, we introduce and analyze a VM in which new opinion states can emerge as the dynamics proceeds. The model mimics the emergence of new information in opinion dynamics due to external influences and/or changes in individuals' beliefs [2, 3]. The model describes a population of N individuals. Initially, there are two opinions present in the population, and each individual is randomly assigned one of these states. At each time step, an individual is chosen at random and then adopts the state of a randomly chosen neighbor. Independent to the copying processes, a new opinion is introduced into the population with probability α. That is, a randomly chosen individual conceives of a new opinion not currently present in the system and becomes this state. The appearance of new opinions enriches the dynamics, adding a new layer of complexity.

Due to the possibility that new opinions emerge for non-zero values of α, the system cannot reach a fully consensus state. This distinguishes the model from the traditional VM, which is recovered only for $\alpha = 0$. Instead, for $\alpha > 0$ the model remains in a dynamically active state indefinitely, characterized by the distribution of the number of opinions in the population and the number of individuals in each opinion state. Through analytical and numerical analysis, we find that the balance between innovation and extinction shapes the number of opinions in the steady state. For low innovation rates, the system tends toward near-consensus, while higher innovation rates lead to greater opinion diversity. We also show that network structure influences opinion dynamics, with greater degree heterogeneity reducing the number of opinions in the system.

Figure 1(a) shows the stationary distribution $P(M)$ of the number of opinions for different innovation rates α. Theoretical predictions (lines) [4] show the great agreement with simulation results (symbols), showing the validity of our analytical approach. At very low innovation rates, the system exhibits a sharp peak around consensus states, while increasing α broadens the distribution and shifts it toward larger numbers of opinions. Figure 1(b) shows the average number M of opinions depending on αN. The results show that innovation sustains an active state, preventing consensus and generating opinion diversity.

In summary, we have introduced and studied a modified voter model with an evolving number of opinion states. The innovation process prevents the system from becoming trapped in consensus and produces a dynamically active state with rich statistical properties. Our analysis demonstrates how the balance of extinction and innovation, as well as network topology, governs the level of opinion diversity. Our study shows how novel ideas and innovations sustain opinion diversity in real social systems.

References

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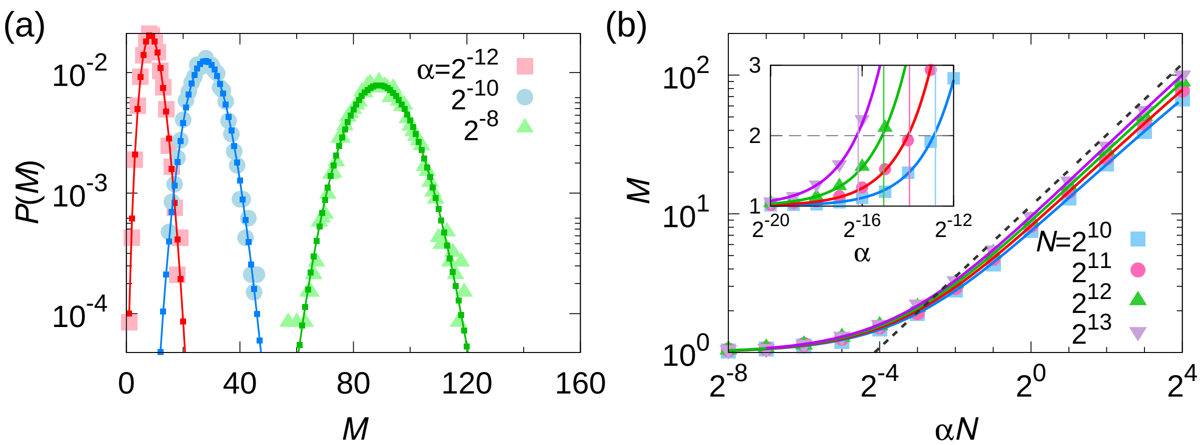

Figure 1: (a) Distribution $P(M)$ of the number of opinions in the stationary state for different innovation rates α. Symbols indicate simulation results and lines show theoretical predictions. (b) Average number of opinions as a function of αN for various population sizes, with simulations (symbols) in good agreement with theoretical predictions (lines). At low α the system remains near consensus, while larger values lead to increased opinion diversity.